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(Reaffirmed 2002)

Indian Standard

GUIDE ON MAINTAINABILITY OF EQUIPMENT

PART 8 MAINTENANCE AND MAINTENANCE SUPPORT PLANNING

Section 3 Maintenance Planning Analysis

UDC 621·31-7 : 621 - 192 (026)

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NEW DELHI 110002

July 1989 **Price Group 2**

Reliability of Electronics and Electrical Components and Equipment Sectional Committee, LTDC 3

FOREWORD

This Indian Standard (Part 8/Section 3) was adopted by the Bureau of Indian Standards on 14 September 1988, after the draft finalized by the Reliability of Electronics and Electrical components and Equipment Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

This guide is intended to make recommendations for the standardization of maintainability practices and to stimulate ideas in the maintainability field. Organizations acquiring items will find the guide useful in assisting them in defining maintainability requirements and associated programmes. Item suppliers will benefit from the use of the guide, gaining and understanding of the requirements for achieving and verifying maintainability objectives.

This Standard (Part 8/Section 3) is one of the series of Indian Standards in the series on 'Guide on maintainability of equipment'. Other standards in this series are:

Part 1	Introduction to maintainability
Part 2	Maintainability requirements in specifications and contracts
Part 3	Maintainability programme
Part 4	Test and diagnostic procedures
Part 5	Maintainability studies during the design phase
Part 6	Maintainability verification
Part 7	Collection, analysis and presentation of data related to maintainability

This Part (Part 8) of the series consists of the following 4 sections:

Section 1	General
Section 2	Maintenance support analysis
Section 3	Maintenance planning analysis
Section 4	Maintenance support resources requirements

In the preparation of this standard, assistance has been derived from the IEC Doc: 56 (Sectt) 194 'Draft IEC Pub 706: Guide on maintainability of equipment. Section Eight : Maintenance and maintenance support planning', issued by the International Electrotechnical Commission (IEC).

Indian Standard

GUIDE ON MAINTAINABILITY OF EQUIPMENT

PART 8 MAINTENANCE AND MAINTENANCE SUPPORT PLANNING

Section 3 Maintenance Planning Analysis

1 SCOPE

1.1 This standard (Part 8/Section 3) provides guidance regarding maintenance planning analysis.

2 REFERENCES

2.1 The Indian Standards listed below are necessary adjuncts to this standard:

IS No.	*Title*
1885 (Part 39) : 1979	Electrotechnical vocabulary: Part 39 Reliability of electronic and electrical items (*first revision*)
11137 (Part 2) : 1984	Analysis techniques for system reliability: Part 2 Procedure for failure mode and effects analysis (FMEA) and failure mode effects and criticality analysis (FMECA)

3 TERMINOLOGY

3.1 For the purpose of this standard, the terms and definitions given in IS : 1885 (Part 39)-1979 shall be applicable.

4 MAINTENANCE PLANNING ANALYSIS

4.1 Maintenance Tasks Identification

4.1.1 Both corrective and preventive maintenance tasks can be identified using the following analysis techniques:

a) Failure mode and effect analysis (FMEA),

b) Reliability centred maintenance (RCM) analysis, and

c) Detailed review of the system/equipment functional and performance requirements.

The FMEA identifies the failure modes of the system and its components thus identifying the corrective maintenance tasks. This analysis is described in IS 11137 (Part 2) : 1984.

The RCM analysis based on FMEA data identifies preventive maintenance requirements:

a) Detect and correct incipient failures either before they occur or before they develop into major defects

b) Reduce the probability of failure,

c) Detect hidden failures that have occurred, and

d) Increase the cost effectiveness of the system's / equipment's maintenance programme.

4.1.2 *Corrective Maintenance Tasks*

An FMEA systematically identities the likesh modes of failure, the possible effects of failure, and the critically of each effect on eacly sion completion, safety or some other outcmime of significance. FMEA will generally be incouded under the reliability pragramme, howlever, FMEA for a system must be developed in conjunction with the MSA tasks due to the necessity of having FMEA results to conduct some MSA tasks. In particular, FMEA provides the basis for built-in and external test specification and evaluation. This coordination should consider the timing of the FMEA, degree of detail required for maintenance level considered, and documentation of results.

4.1.3 *Preventive Maintenance Tasks*

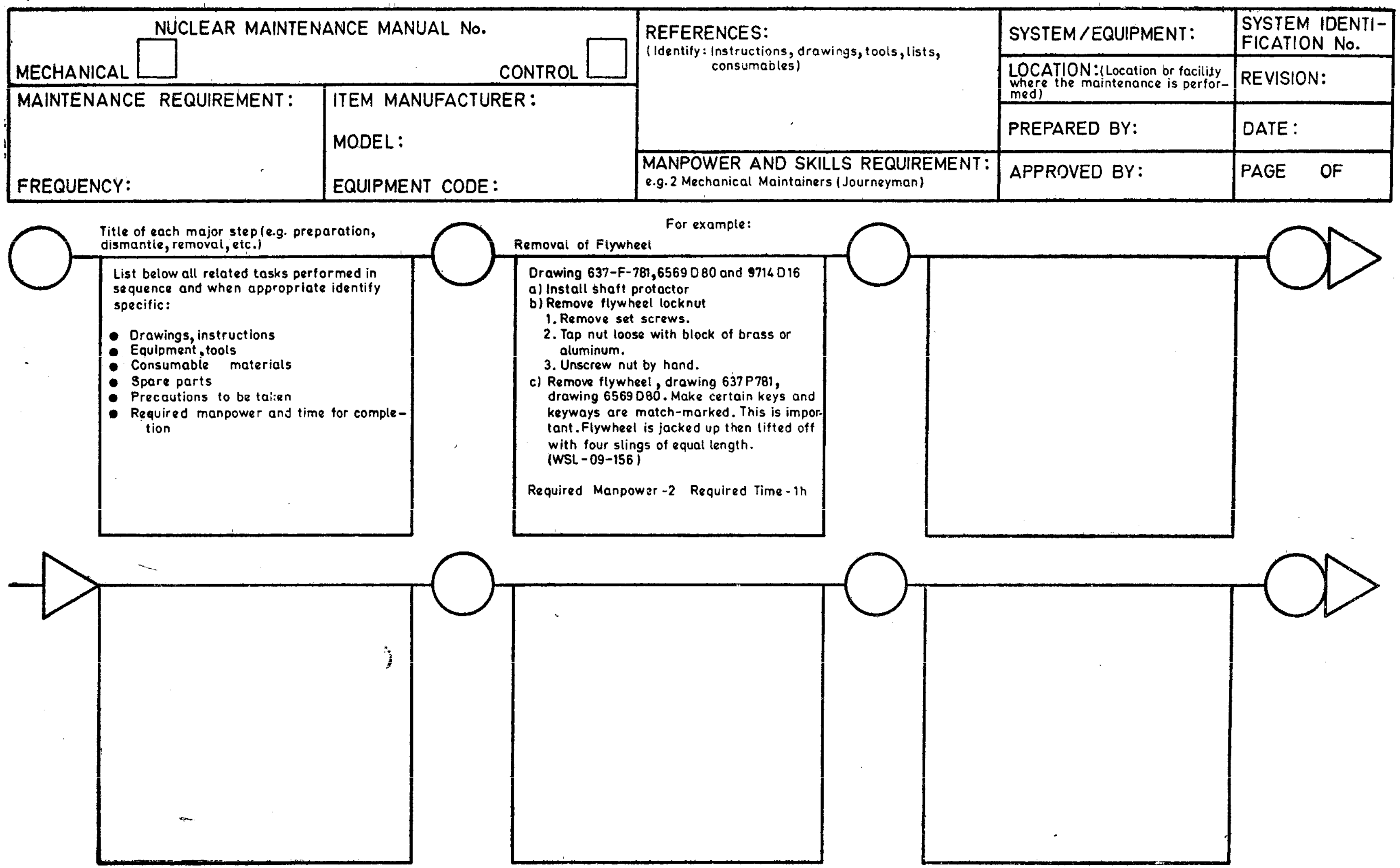
Reliability centered maintainability (RCM) analysis consists of a systematic approach of analyzing system/equipment reliability and safety data to determine the feasibility and desirability of preventive maintenance tasks, to highlight maintenance problem areas for design review consideration, and to establish the most effective preventive maintenance programme for the new system/equipment. RCM logic is applied to the individual failure modes of each item in the system/equipment identified during the FMEA through a progressive determination of how impending failures can be detected and corrected in order to preserve, to the degree possible, the inherent levels of reliability and safety in the system/equipment.

4.2 Maintenance Task Analysis

Maintenance task analysis should be performed for each of the significant maintenance tasks identified. The basic procedure to be followed should be outlined in a format of a logic flow diagram. A fault isolation process and prerequisites should be first outlined followed by the step-by-step procedure for each significant failure identified in FMEA for the item and preventive maintenance tasks identified in RCM analysis. The following information should be recorded:

a) Maintenance requirements in terms of ultimate purpose of maintenance action (for example, remove and replace, adjust, etc);

b) Maintenance frequency expected or recommended;



NUCLEAR MAINTENANCE MANUAL No. MECHANICAL ☐ CONTROL ☐		REFERENCES: (Identify: Instructions, drawings, tools, lists, consumables)	SYSTEM / EQUIPMENT:	SYSTEM IDENTIFICATION No.
MAINTENANCE REQUIREMENT:	ITEM MANUFACTURER:		LOCATION: (Location or facility where the maintenance is performed)	REVISION:
	MODEL:		PREPARED BY:	DATE:
FREQUENCY:	EQUIPMENT CODE:	MANPOWER AND SKILLS REQUIREMENT: e.g. 2 Mechanical Maintainers (Journeyman)	APPROVED BY:	PAGE OF

Title of each major step (e.g. preparation, dismantle, removal, etc.)

List below all related tasks performed in sequence and when appropriate identify specific:

- Drawings, instructions
- Equipment, tools
- Consumable materials
- Spare parts
- Precautions to be taken
- Required manpower and time for completion

For example:

Removal of Flywheel

Drawing 637-F-781, 6569 D 80 and 9714 D 16

a) Install shaft protector

b) Remove flywheel locknut

1. Remove set screws.
2. Tap nut loose with block of brass or aluminum.
3. Unscrew nut by hand.

c) Remove flywheel, drawing 637 P 781, drawing 6569 D 80. Make certain keys and keyways are match-marked. This is important. Flywheel is jacked up then lifted off with four slings of equal length. (WSL-09-156)

Required Manpower - 2 Required Time - 1h

FIG. 1 DEVELOPMENT OF MAINTENANCE PLAN

c) Number of personnel, specially and skill levels necessary to perform each task;

d) Location or facility required to perform the maintenance tasks described;

e) Maintenance tasks are identified in sequential order of performance. Each task should be described in sufficient technical detail.

f) Tools and test equipment required to accomplish the maintenance tasks in required sequence;

g) Spare parts and consumable material required to perform maintenance tasks; and

h) Time estimate to complete each task and the total time required to complete the sequence.

An example of the maintenance manual worksheet is shown in Fig. 1.

4.3 Repair Level Analysis (RLA)

In defining the detailed maintenance concept and establishing criteria for equipment design, it is necessary to determine whether items should be repaired at the organisational, intermediate or depot line of maintenance or discarded in the event of failure. The objectives of the analysis is to define appropriate lines and levels of maintenance to minimize the costs subject to availability constraints.

This analysis starts in the conceptual phase of system/equipment life cycle where overall concept is analyzed and becomes more detailed as the design progresses.

4.3.1 Repair level analysis is to a process which permits the following:

a) A systematic decision-making process
  1) What to do with items that failed,
  2) Apply the same criteria to all items, and
  3) Eliminate intuitive approach.

b) Comparison of alternative repair policies:
  1) Replace at failure,
  2) Repair in place or in the local shop,
  3) Repair in centralized facility, and
  4) Best mix of local and central repair.

c) Application of life cycle cost (LCC) analysis:
  1) LCC, economic comparison of repair alternatives when all economic factors are considered, and
  2) Partial LCC, only some categories being considered, for example, consider only incremental costs.

d) Consideration of non-economic implication:
  1) Assurance of safety, and
  2) Operational environment.

4.3.2 Items of equipment for analysis should be carefully selected and could be limited to maintenance of significant items.

The following information provides input to RLA:

a) Equipment operational data number, location, lifetime, etc;

b) Feasible repair alternatives:

c) Cost factors;

d) Repair personnel and resources;

e) Equipment reliability and maintainability data; and

f) Turn around and transportation time between repair facilities.

4.3.3 The output from the conceptual RLA provides input into the development of the maintenance concept and the repair policy for the system/equipment.

The output from the detailed RLA provides maintenance level assignment for each item and provides input into the maintenance task analysis and the development of maintenance plan.

4.4 Maintenance Plan

4.4.1 Individual maintenance task analysis worksheets should be consolidated into system/equipment maintenance plan. This plan should define the overall maintenance and support resources to achieve operational requirements at optimum life cycle costs. The overall plan provides information whether the specified maintainability goals are met and whether further activities are required to meet the project requirements. The development process of the maintenance plan is shown in Fig. 2.

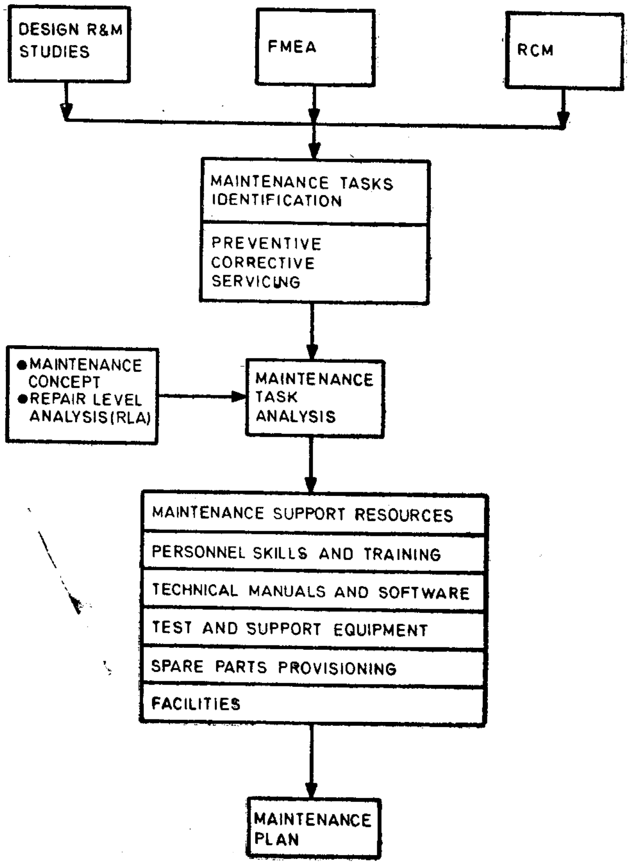

DESIGN R&M STUDIES
FMEA
RCM
MAINTENANCE TASKS IDENTIFICATION
PREVENTIVE
CORRECTIVE
SERVICING
●MAINTENANCE CONCEPT
●REPAIR LEVEL ANALYSIS(RLA)
MAINTENANCE TASK ANALYSIS
MAINTENANCE SUPPORT RESOURCES
PERSONNEL SKILLS AND TRAINING
TECHNICAL MANUALS AND SOFTWARE
TEST AND SUPPORT EQUIPMENT
SPARE PARTS PROVISIONING
FACILITIES
MAINTENANCE PLAN

FIG. 2 MAINTENANCE MANUAL WORK SHEET

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